Proposal Submitted to the
U.S. Army Corps of Engineers, Portland District

by

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Title:	**Avian Predation on Juvenile Salmonids in the Columbia River Estuary**
Requested Dates:	**March 1, 2005 – September 30, 2005**
Proposing Agencies:	USGS-Oregon Cooperative Fish and Wildlife Research Unit Department of Fisheries and Wildlife 104 Nash Hall Oregon State University Corvallis, OR 97331-3803

PROJECT SUMMARY

Piscivorous waterbirds (i.e., terns, cormorants, gulls) are having a significant impact on survival of juvenile salmonids in the Columbia River estuary. Prior to management the Caspian tern (*Sterna caspia*) population nesting on Rice Island, an artificial dredged material disposal island in the estuary, consumed an estimated 5.4 – 14.2 million juvenile salmonids in both 1997 and 1998. This represents about 5 - 15 % of all salmonid smolts reaching the estuary during those two migration years. Additionally, double-crested cormorants (*Phalacrocorax auritus*) and glaucous-winged/western gulls (*Larus glaucescens* X *L. occidentalis*) nesting in the Columbia River estuary consumed about 2 – 9 million and 0.4 – 4 million juvenile salmonids in 1998, respectively. Due to growing concern regarding the impacts of avian predators on recovery of ESA-listed salmonids, regional fish and wildlife managers called for immediate management action to reduce losses of juvenile salmonids to Caspian terns in the estuary.

A management plan implemented in 2000 sought to relocate the Rice Island tern colony to a new site on East Sand Island, 21 km closer to the ocean, where it was hoped terns would consume significantly fewer juvenile salmonids. Over 94% of the terns shifted to East Sand Island in 2000, where nesting success was nearly four times higher than at the Rice Island colony. Juvenile salmonids comprised 47% of the prey items of terns nesting at East Sand Island, compared to 90% of prey items at Rice Island. The relocation of nearly all the nesting terns from Rice Island to East Sand Island resulted in a sharp drop in consumption of juvenile salmonids. Total smolt consumption by Caspian terns nesting in the Columbia River estuary in 2000 was estimated at 7.3 million (95% confidence interval = 6.1 - 8.6 million). This represents a reduction of about 4.4 million (38%) compared to the 1999 smolt consumption estimate.

In 2001–2003, all Caspian terns nesting in the Columbia River estuary used restored habitat on East Sand Island. The size of the East Sand Island colony was ca. 8,325 pairs in 2003, by far the largest known Caspian tern nesting colony in the world, and representing about two-thirds of all Caspian terns in the Pacific coast population. Tern nesting success at the East Sand Island colony in 2001–2003 was high (1.4, 1.1, and 1.1 young raised per nesting pair, respectively), apparently a reflection of high forage fish availability. The proportion of juvenile salmonids in the diet in 2003 (24%) was the lowest ever recorded for terns nesting in the estuary. Consumption of juvenile salmonids by the East Sand Island tern colony in 2003 was approximately 4.2 million smolts (95% c.i. = 3.5–4.8 million), ca. 8.2 million fewer smolts consumed compared to 1998, when all terns nested on Rice Island.

In 2005, we will continue to monitor and evaluate management initiatives implemented to reduce Caspian tern predation on juvenile salmonids in the Columbia River estuary. This research activity is a key component of the April 2002 Settlement Agreement, which permitted the resumption of Caspian tern management in the estuary. A permanent injunction against tern management had previously been awarded to plaintiffs in their suit against the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service. We will also continue to monitor population size, nesting success, and diet composition of

double-crested cormorant colonies in the Columbia River estuary; consumption of juvenile salmonids by cormorants nesting in the estuary equals or exceeds that of Caspian terns and may contribute significantly to smolt mortality. We will use a bioenergetics modeling approach to quantify the numbers of juvenile salmonids consumed by Caspian terns and double-crested cormorants in the Columbia River, and to convert those numbers into predation rates on particular stocks of Columbia Basin salmonids. In addition, we will evaluate the factors that influence the vulnerability of various salmonid species and stocks (especially steelhead) to avian predation in the Columbia River estuary. Finally, we will provide technical assistance to regional fish and wildlife management agencies in developing short- and long-term management plans to reduce avian predation on juvenile salmonids in the Columbia River estuary.

PROJECT DESCRIPTION

Background

Published research suggests that avian predation can, under some conditions, be a substantial source of mortality for juvenile salmonids. Mace (1983) estimated that 10.4-31.7% of hatchery-released chinook smolts in the Big Qualicum River on Vancouver Island succumbed to avian predation within just 2 km of the hatchery. A subsequent study on the same river estimated that predation by merganser broods alone accounted for 24-65% of smolt production (Wood 1987). Feltham (1995) estimated that mergansers removed 3-16% of smolt production on two Scottish rivers. In a 3-year study on the Penobscot River in Maine, predation by double-crested cormorants on hatchery-reared Atlantic salmon accounted for 7.5% to 9.2% of the run (Krohn and Blackwell 1996; Blackwell 1995). Perhaps most impressive is the estimate by Kennedy and Greer (1988) that 51–66% of smolts from a wild run in an Irish river were lost to cormorant predation.

Aggregations of piscivorous birds have been observed on the Columbia River near dams (Ruggerone 1986; Steuber et al. 1993; Jones et al. 1996), at hatchery (Schaeffer 1991; Schaeffer 1992) and barge release points (K. Collis, CRITFC, pers. obs.), and in the estuary (Bevan et al. 1994) near the large waterbird breeding colonies at Rice and East Sand islands. Predation by birds on radio-tagged chinook salmon smolts has been documented in the tailraces below The Dalles and John Day dams and in the Columbia River estuary (C. Schreck, OSU, pers. comm.). In 1995, 11.3% (11/97) of radio-tagged yearlings and 4.1% (4/71) of subyearlings fell prey to gulls below The Dalles Dam (J. Snelling, OSU, pers. comm.). In 1996 and 1997, between 10% and 30% of radio-tagged chinook yearlings migrating through the Columbia River estuary were consumed by terns or cormorants nesting in that area (C. Schreck, OSU, pers. comm.). The bioenergetics approach of estimating prey consumption yielded estimates of 5.4–14.2 million juvenile salmonids consumed by the Rice Island Caspian tern colony in both 1997 and 1998 (Roby et al. 2003). This is equivalent to 5–15% of the estimated number of out-migrating smolts to reach the estuary in those two years.

Caspian terns (*Sterna caspia*) are one of the more important predators of juvenile salmonids in the Columbia River Basin. Caspian terns are the largest tern species in the

world and strictly piscivorous. Until the 2000 breeding season, Rice Island, a dredged material disposal island in the Columbia River estuary, was home to the largest Caspian tern colony in North America (ca. 8,000 nesting pairs; Roby et al. 2002), and perhaps the world (Cuthbert and Wires 1999). Numbers of breeding adults in the Columbia River estuary have increased about an order of magnitude since the colony was first established on Rice Island in 1986 (Roby et al. 2002).

Double-crested cormorants (*Phalacrocorax auritus*) are a common piscivore in the Columbia River estuary. A large cormorant colony has become established on a rock jetty at the west end of East Sand Island, at river mile 5 in the estuary. Just 15 years ago there were no double-crested cormorants nesting on East Sand Island and cormorant nesting pairs throughout the estuary numbered in the hundreds. Now East Sand Island supports the largest double-crested cormorant colony on the Pacific coast of the U.S. and Canada (Carter et al. 1995; Anderson 2002). East Sand Island, plus nearby pilings and channel markers, supported a total population of roughly 11,000 breeding pairs in 2003 (Anderson 2002, CBR 2003). This is consistent with continent-wide growth in double-crested cormorant populations and increasing frequency of conflicts with salmonid fisheries (Nettleship and Duffy 1995). We estimate that cormorants nesting in the Columbia River estuary consumed between 2.2 and 9.2 million juvenile salmonids in 1998 (Collis et al. 1999). Given the size and population trajectory of the East Sand Island cormorant colony, plus predation by the East Sand Island Caspian tern colony, total losses of juvenile salmonids to avian predators in the Columbia River estuary comprises a significant proportion of several runs.

The magnitude of predation on juvenile salmonids by Caspian terns nesting on Rice Island led to management action in 1999. A pilot study was conducted to determine whether the Rice Island tern colony could be relocated 26 km (16 miles) closer to the ocean on East Sand Island, where it was hoped terns would consume fewer salmonids. Habitat restoration, social attraction (decoys and audio playback systems), and selective predator removal were used to encourage terns to nest on East Sand Island. About 1,400 pairs of Caspian terns nested at the new colony site on East Sand Island in 1999. In 2000, about 8,500 pairs of Caspian terns nested on East Sand Island, or 94% of all terns nesting in the estuary. In 2001–2002, all Caspian terns nesting in the Columbia River estuary used East Sand Island, with approximately 9,000, 9,900, and 8,300 pairs nesting at the site in 2001, 2002, and 2003, respectively.

Our results also indicate that relocating the tern colony to East Sand Island enhanced the productivity of Caspian terns nesting in the Columbia River estuary. Nesting success of Caspian terns on East Sand Island (0.57–1.39 young raised per breeding pair on average during 1999–2003) was consistently higher than for terns nesting on Rice Island, both prior to tern management (1997–1998: 0.06–0.45 young raised per breeding pair) and post-management (1999–2000: 0.15–0.55 young raised per breeding pair). The productivity measured at Rice Island was considerably lower than at other well-studied Caspian tern colonies in North America (range of 0.6–1.6 young raised per breeding pair; Cuthbert and Wires 1999).

Terns nesting on East Sand Island foraged more in marine and brackish water habitats than did the terns nesting on Rice Island (Anderson 2003). The diet of East Sand Island terns averaged between 24% and 47% salmonids during the years 1999-2003, compared to the diet of Rice Island terns, which consisted of 77% and 90% salmonids in 1999 and 2000, respectively. The relocation of all nesting terns from Rice Island to East Sand Island resulted in a sharp drop in consumption of juvenile salmonids by terns nesting in the Columbia River estuary. Total consumption of juvenile salmonids in 2000, when most terns nested on East Sand Island, was estimated at 8.2 million (95% c.i. = 6.7–9.7 million), a reduction of about 4.2 million (34%) compared to 1998. Total smolt consumption by terns nesting on East Sand Island in 2001–2003, when all terns nesting in the estuary used East Sand Island, was approximately 5.8, 6.5, and 4.2 million, respectively. This represents 53%, 48%, and 66% reductions in estimated smolt consumption compared to 1998. Caspian terns nesting on East Sand Island in 2003 still consumed an estimated 3.5 – 4.8 million smolts, with some ESA-listed stocks still suffering significant losses to tern predation (Ryan et al. 2001a, Ryan et al. 2001b). To achieve further reductions in consumption of juvenile salmonids by Caspian terns in the estuary it will likely be necessary to reduce the size of the East Sand Island tern colony by relocating a portion of the colony to alternative sites outside the estuary.

Despite the higher nesting success of Caspian terns nesting on East Sand Island and reductions in tern predation on juvenile salmonids, several bird conservation groups sued the federal government (USACE, USFWS) to stop management of Caspian terns in the Columbia River estuary. The suit was successful, and in August 2001 a federal district judge in Seattle awarded the plaintiffs a permanent injunction against management of any fish-eating birds in the Columbia River estuary to benefit salmonids. Had the injunction stood, all Caspian terns nesting at East Sand Island would likely have returned to the former colony site on Rice Island within a few years. In April 2002, however, a Settlement Agreement was reached between plaintiffs and the federal government that allowed management to resume with several conditions. One of those conditions was that research efforts to monitor and evaluate the effects of management on Caspian tern colony size, nesting success, and diet composition would be maintained.

Rationale and Significance of Proposed Research

Caspian terns nesting on East Sand Island continue to consume 4–6 million juvenile salmonids in the Columbia River estuary annually, despite the reduction in smolt consumption associated with relocation of the tern colony from Rice Island to East Sand Island (Roby et al. 2002, CBR 2003). Based on smolt PIT tags recovered from the East Sand Island tern colony in 2000 and 2001 (Ryan et al. 2001a, 2001b), some ESA-listed salmonid stocks from the Columbia River basin, especially steelhead, continue to suffer significant losses to tern predation. Approximately two-thirds of Caspian terns in the Pacific coast population of North America are now nesting at East Sand Island, the sole Caspian tern colony site on the coast of the Pacific Northwest (Cuthbert and Wires 1999, Wires and Cuthbert 2000). Risks to both Columbia Basin salmonids and the tern population may be reduced if a portion of the Caspian tern colony in the Columbia River estuary was relocated to a number of smaller tern colonies outside the Columbia River.

Diets of double-crested cormorants in the Columbia River estuary, especially those nesting on Rice Island or nearby channel markers, include a significant proportion of juvenile salmonids (Collis et al. 2001; Collis et al. 2002a). The cormorant colonies in the estuary are also large, grew rapidly in the 1990's (Collis et al. 2002a), and continue to grow (Anderson 2002). The double-crested cormorant colony on East Sand Island now numbers over 10,500 breeding pairs, the largest known colony of this species along the Pacific coast of North America (Anderson 2002). Cormorants are large birds, with concomitant high food requirements. Finally, shifts in the nesting distribution of Caspian terns in the estuary may affect diet composition and smolt consumption rates of cormorants through compensation, contributing further to smolt losses from double-crested cormorant predation in the estuary. These factors taken together suggest that the magnitude of predation by double-crested cormorants on juvenile salmonids in the Columbia River estuary may be sufficient to warrant management, now or in the future. An understanding of the ecology of nesting double-crested cormorants on East Sand Island and predation on juvenile salmonids by cormorants will help resource managers develop and implement effective management initiatives to reduce predation, if warranted.

Research, monitoring, and evaluation of avian predation on juvenile salmonids in the Columbia River estuary will have profound short- and long-term implications for the conservation and management of both salmon and birds. Current management actions have focused on relocating the Caspian tern colony at Rice Island in the upper estuary to East Sand Island, near the mouth of the Columbia River. This shift in nesting distribution has reduced consumption of juvenile salmonids by 6–8 million smolts annually (CBR 2003). Future management actions, to be described in a forthcoming interagency EIS, may seek to shift some of the Caspian terns nesting in the estuary to newly restored and existing colony sites along the Pacific Coast and inland as a way to further reduce their impacts on Columbia Basin salmonids. Future management actions may also be initiated with regard to limiting double-crested cormorant predation on juvenile salmonids in the Columbia River estuary. This study will help determine to what extent bird predation is still a problem in the Columbia River estuary, which piscivorous waterbird populations pose the greatest risk to salmonid survival, and how management in the estuary affects the distribution of breeding piscivorous waterbirds elsewhere in the Pacific Northwest. These data will be important in assuring that smolt survival gains associated with bird management in the estuary are not offset by increased bird predation on juvenile salmonids at other sites. Perhaps more importantly, data collected as part of this study will help guide managers in developing management initiatives for the Columbia River estuary that are science-based, defensible, cost-effective, and have a high probability of success.

2005 STATEMENT OF WORK

Objective 1. Research, monitor, and evaluate predation by Caspian terns on salmonid smolts in the Columbia River estuary.

Task 1.1 Determine the size, habitat use, nesting success, and factors limiting nest success of the Caspian tern colony on East Sand Island.

Methods: Colony site preparation (i.e., social attraction), colony monitoring, aerial photo census, aerial photography interpretation.

Task 1.2 Determine diet composition and consumption of juvenile salmonids by Caspian terns nesting on East Sand Island.

Methods: Monitoring of diet on-colony, collect diet samples off-colony, determine diet composition from fatty acid signatures, use bioenergetics modeling to estimate smolt consumption, estimate salmonid smolt availability in the estuary, analysis of smolt PIT tag detections on-colony.

T**ask 1.3** Detect the formation of new Caspian tern colonies at other dredged material disposal sites in the estuary (e.g., Rice Island, Miller Sands Spit, Pillar Rock Sands).

Methods: Semi-weekly surveys of dredged material disposal islands in the upper estuary, assessment of incipient breeding behavior by adult terns roosting at these sites.

Task 1.4 Develop predictions for future population dynamics of Caspian terns nesting on East Sand Island that will allow reliable projections of predation rates on Columbia Basin salmonids.

Methods: Band fledgling Caspian terns at East Sand Island, systematically resight banded terns on-colony and at other sites, develop life tables and demographic models for the tern population, extrapolate tern population trends and impact on survival of juvenile salmonids in the estuary based on current survival, fecundity, and diet composition.

Task 1.5 Determine those factors that influence per-capita smolt consumption rates by Caspian terns nesting at East Sand Island to support reliable projections of predation rates on Columbia Basin salmonids.

Methods: Assess the relative effects of colony size, colony nesting success, availability of juvenile salmonids, availability of alternative prey, and competition with other fish-eating birds on per-capita tern predation rates on salmonid smolts.

Task 1.6 Determine the accuracy of tern predation rates on salmonids based on

smolt PIT tag recoveries on-colony.

Methods: Determine the proportion of ingested smolt PIT tags that are deposited on colony by determining egestion route, egestion timing, and destruction rate of PIT tags ingested by captive and free-ranging Caspian terns.

Task 1.1.7 Determine the relative importance of factors that influence the vulnerability of juvenile salmonids to predation by terns in the estuary (e.g., salmonid species, ESU, stock, passage history, river flows, passage timing, and health status).

Methods: In cooperation with NOAA, use PIT tags recovered on colony to (1) assess relative vulnerability of various salmonid stocks and ESU's, and (2) evaluate the affects of river conditions, dam operations, and fish out-migration histories on predation vulnerability.

Objective 2. Research, monitor, and evaluate predation by double-crested cormorants on salmonid smolts in the Columbia River estuary.

Task 2.1 Determine the size, habitat use, nesting success, and factors limiting nest success of the double-crested cormorant colony on East Sand Island.

Methods: Colony monitoring, aerial photo census, and interpretation of aerial photography.

Task 2.2 Determine diet composition and consumption of juvenile salmonids by double-crested cormorants nesting on East Sand Island.

Methods: Diet sample collection off-colony, identification of species of salmonids in the diet using genetic fingerprinting and fatty acid signature techniques, bioenergetics modeling, estimation of salmonid smolt availability in the estuary, analysis of smolt PIT tag detections on-colony.

Task 2.3 Survey and monitor the size, nesting success, and (where possible) the diet composition of colonies of double-crested cormorants at other sites in the estuary (e.g., Rice Island, Miller Sands Spit, Miller Sands channel markers).

Methods: Weekly surveys of islands, channel markers, and pilings in the upper estuary for nesting cormorants throughout the breeding season, assessment of diet composition through collection of nestling regurgitations.

Task 2.4 Develop predictions for future population dynamics of double-crested cormorants nesting in the Columbia River estuary that will allow reliable projections of predation rates on Columbia Basin salmonids.

Methods: Develop simple deterministic demographic models for the cormorant population, extrapolate cormorant population trends and impact on survival of juvenile salmonds in the estuary based on currently available life table and diet composition information.

Task 2.5 Determine those factors that influence per-capita smolt consumption rates by double-crested cormorants nesting on East Sand Island to support reliable projections of predation rates on Columbia Basin salmonids.

Methods: Assess the relative effects of colony size, colony nesting success, availability of juvenile salmonids, availability of alternative forage fishes, and competition with other fish-eating birds on per-capita cormorant predation rates on salmonid smolts.

Task 2.6 Determine the relative importance of factors that influence the vulnerability of juvenile salmonids to predation by cormorants in the estuary (e.g., salmonid species, ESU, stock, passage history, river flows, passage timing, and health status).

Methods: In cooperation with NOAA, use PIT tags recovered on colony to (1) assess relative vulnerability of various salmonid stocks and ESU's, and (2) evaluate the affects of river conditions, dam operations, and fish out-migration histories on predation vulnerability.

Objective 3. Monitor the numbers and behavior of California brown pelicans roosting on East Sand Island *(ESA-mandated monitoring)*

Task 3.1 Assess the effects of this project's research and monitoring activities on the behavior and numbers of endangered California brown pelicans roosting on East Sand Island.

Methods: Use semi-weekly boat-based censuses of brown pelicans roosting on East Sand Island; use behavioral observations to monitor the frequency and types of disturbance to roosting pelicans (including researcher activities) and the magnitude of response by pelicans.

COORDINATION AND COOPERATION OF RESEARCH EFFORT

This project will be conducted cooperatively by the USGS-Oregon Cooperative Fish and Wildlife Research Unit at Oregon State University and Real Time Research. Direction for the monitoring and evaluation component of this project comes from regional resource management agencies, which includes representatives from Bonneville Power Administration (POC: Dorothy Welch), U.S. Army Corps of Engineers (POCs: Bob Willis, Geoff Dorsey, Rebecca Kalamasz, Scott Dunmire), Northwest Power and Conservation Council (POCs: Peter Paquet, Patty O'Toole, Doug Marker), NOAA Fisheries (POCs: Ben Meyer, Cathy Tortorici, John Ferguson, Tom Good, Brad Ryan), U.S. Fish and Wildlife Service (POCs: Tara Zimmerman, Nanette Seto), Oregon Department of Fish and Wildlife (POC: Charlie Bruce), Washington Department of Fish and Wildlife (POCs: Rocky Beach, Chris Thompson), and the Columbia River Inter-Tribal Fish Commission (POC: Dale McCullough). We anticipate that additional collaborative and cooperative arrangements will be forged with other agencies and research organizations currently engaged in or planning work on the Columbia River.

FACILITIES AND EQUIPMENT

Fieldwork will be focused in the Columbia River estuary. This work will be conducted out of a field station in either Chinook, WA or Astoria, OR. Three boats capable of handling conditions encountered in the Columbia River estuary will be needed. The USGS-Oregon Cooperative Fish and Wildlife Research Unit has a 20 ft. Boston Whaler, an 18 ft. Alumaweld, and an Achilles inflatable that are fully equipped. The Unit will provide boats for use on the project in return for maintenance, repair, and/or replacement in the event of normal wear and tear, damage, or loss of these watercraft and associated equipment (outboard motors, trailers, etc.).

Since the project "Avian Predation on Juvenile Salmonids in the Lower Columbia River" was initiated in 1997, the project has acquired a considerable quantity of reusable field supplies and equipment that are dedicated to this project. These include two portable buildings for use as field camps, tents, camp supplies, hundreds of Caspian tern decoys, complete audio playback systems for the field, several sturdy plywood blinds for colony observations, optical equipment for colony observations, and a wide variety of other miscellaneous field supplies.

The Department of Fisheries and Wildlife, Oregon State University will provide lab facilities. This laboratory is fully equipped to conduct analyses of proximate composition and energy content of fish prey for piscivorous birds. Through our collaborator, Dr. G. Henk Visser, at the University of Groningen in The Netherlands, we have access to all the laboratory and equipment required for analysis of biological samples for studies using the doubly labeled water technique for measuring field metabolic rates of fish-eating birds.

REPORTING

Because of funding agency constraints, the funding detailed in the attached budget only covers the cost of this project through 30 September 2005, the end date for federal FY05. Although data collection in the field will be complete by the end of the federal fiscal year, data analysis and write-up will not. A draft 2005 season summary describing results of this project will be submitted to the funding agency by December 2005, contingent on receiving support in FY05, during the data analysis and write-up phase. The final season summary incorporating peer review comments will be submitted by March 1, 2006. The season summary, as well as weekly in-season reports, will be made available on the web at www.columbiabirdresearch.org. A proposal for subsequent years of this study will be submitted upon request. Deliverables in subsequent years of this study will follow the schedule outlined above, to include a final project completion report due one year after the completion of field work.

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